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NNMI Industry Day: Smart Manufacturing AMO Overview

February 25, 2015

Atlanta, GA

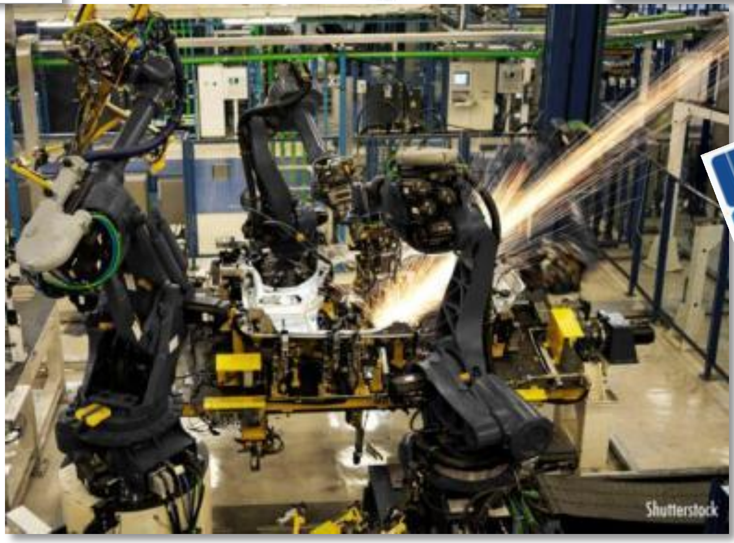
Mark Johnson

Director

Advanced Manufacturing Office

www.manufacturing.energy.gov

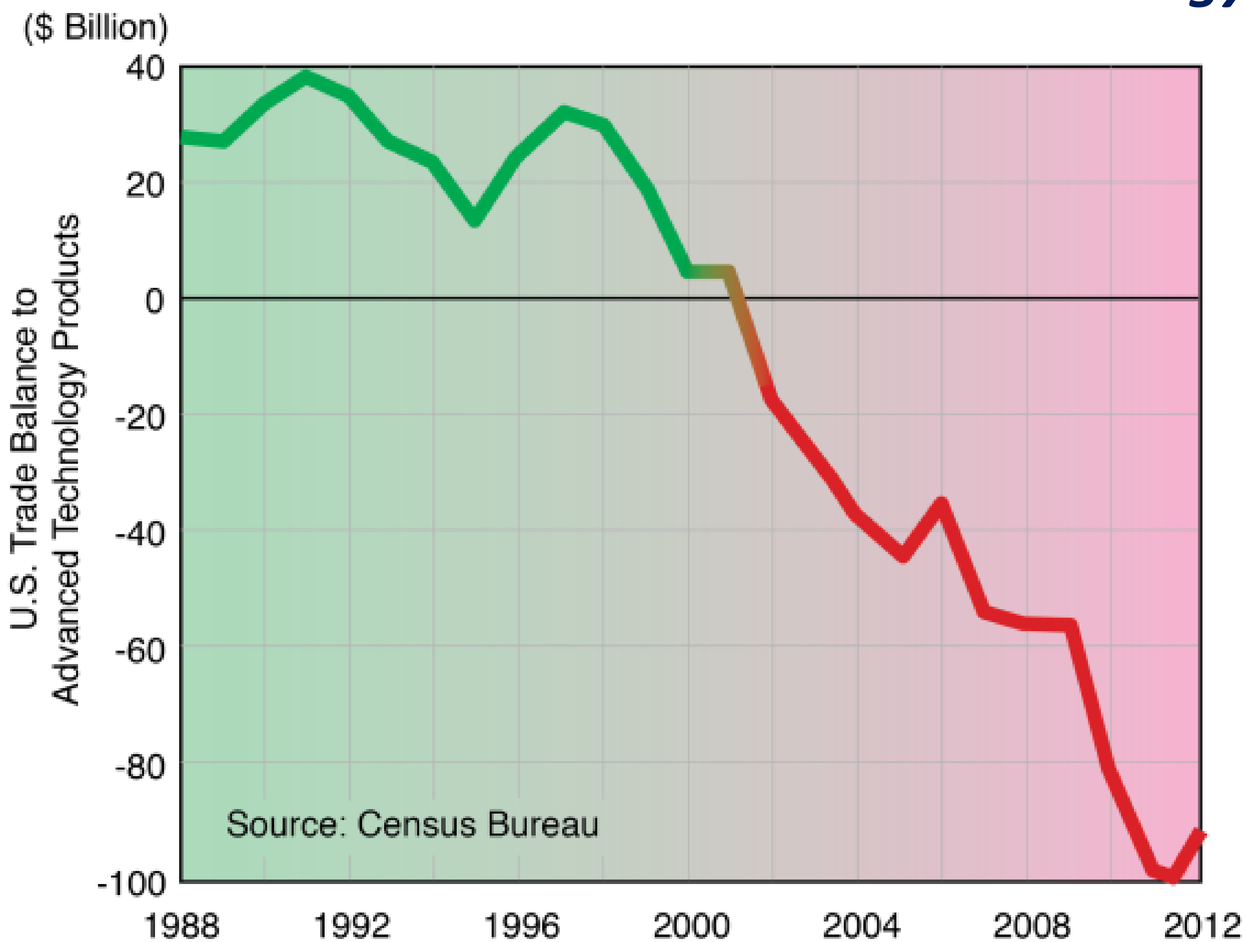
Status Quo: Products invented here, and made elsewhere



Significance of U.S. Manufacturing

12% of U.S. GDP, **12** million U.S. jobs, **60%** of U.S. Exports

U.S. Trade Balance of *Advanced Technology*



Swung to historic deficit, lost 1/3rd of workforce

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Clean Energy: Nexus of Opportunities

- Energy self-reliance
- Stable, diverse energy supply

- Competitiveness in clean energy
- Domestic jobs

- Clean air
- Climate change
- Health

Strategic Framework for Advanced Manufacturing

Climate Action Plan: Efficiency and Sustainability

National Economic Council: Manufacturing Competitiveness

Quadrennial Energy Plan: End-Use Sector Focus

Quadrennial Technology Plan: DOE Technology Area Focus

Clean Energy Manufacturing Tech-Team: Cross-Cutting Impact

Efficiency in Manufacturing Processes (Energy, CO_2)

Enabling Materials and Technologies for Clean Energy

Modalities: Technology Assistance and Technology Development

Technology Development: R&D Projects and R&D Facilities

National Manufacturing Policy & DOE's Role


REPORT TO THE PRESIDENT ON ENSURING AMERICAN LEADERSHIP IN ADVANCED MANUFACTURING

Executive Office of the President
President's Council of Advisors on Science and Technology

JUNE 2011

A NATIONAL STRATEGIC PLAN FOR ADVANCED MANUFACTURING

Executive Office of the President
National Science and Technology Council

FEBRUARY 2012

REPORT TO THE PRESIDENT ON CAPTURING DOMESTIC COMPETITIVE ADVANTAGE IN ADVANCED MANUFACTURING

Executive Office of the President
President's Council of Advisors on Science and Technology

JULY 2012

NATIONAL NETWORK FOR MANUFACTURING INNOVATION: A PRELIMINARY DESIGN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

JANUARY 2013

- DOE is active across the pillars of Advanced Manufacturing
- DOE is a leader in **advanced manufacturing innovation** and implementing the **National Network for Manufacturing Innovation (NNMI)**

NNMI:

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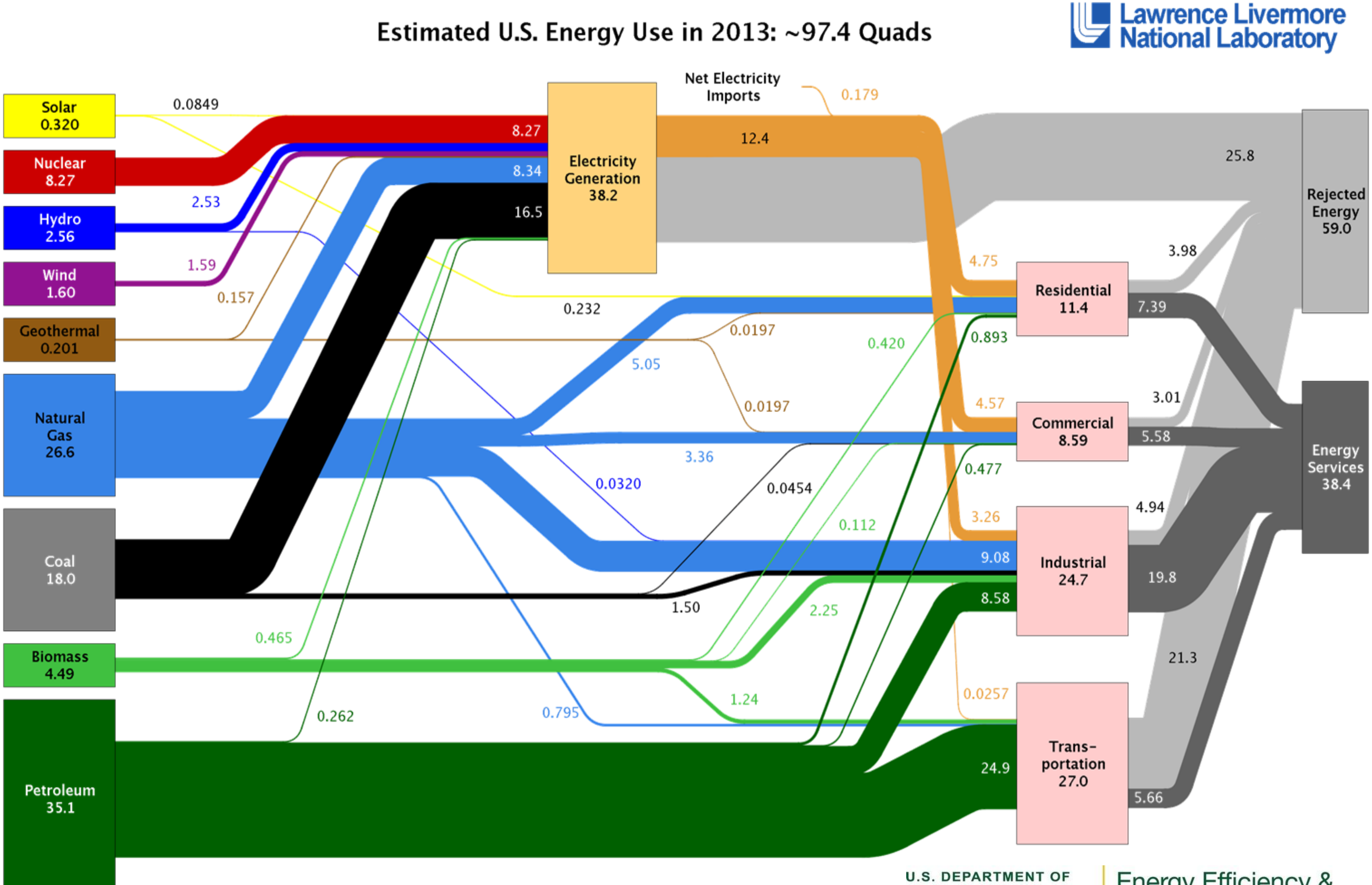
Energy Consumption by Sector



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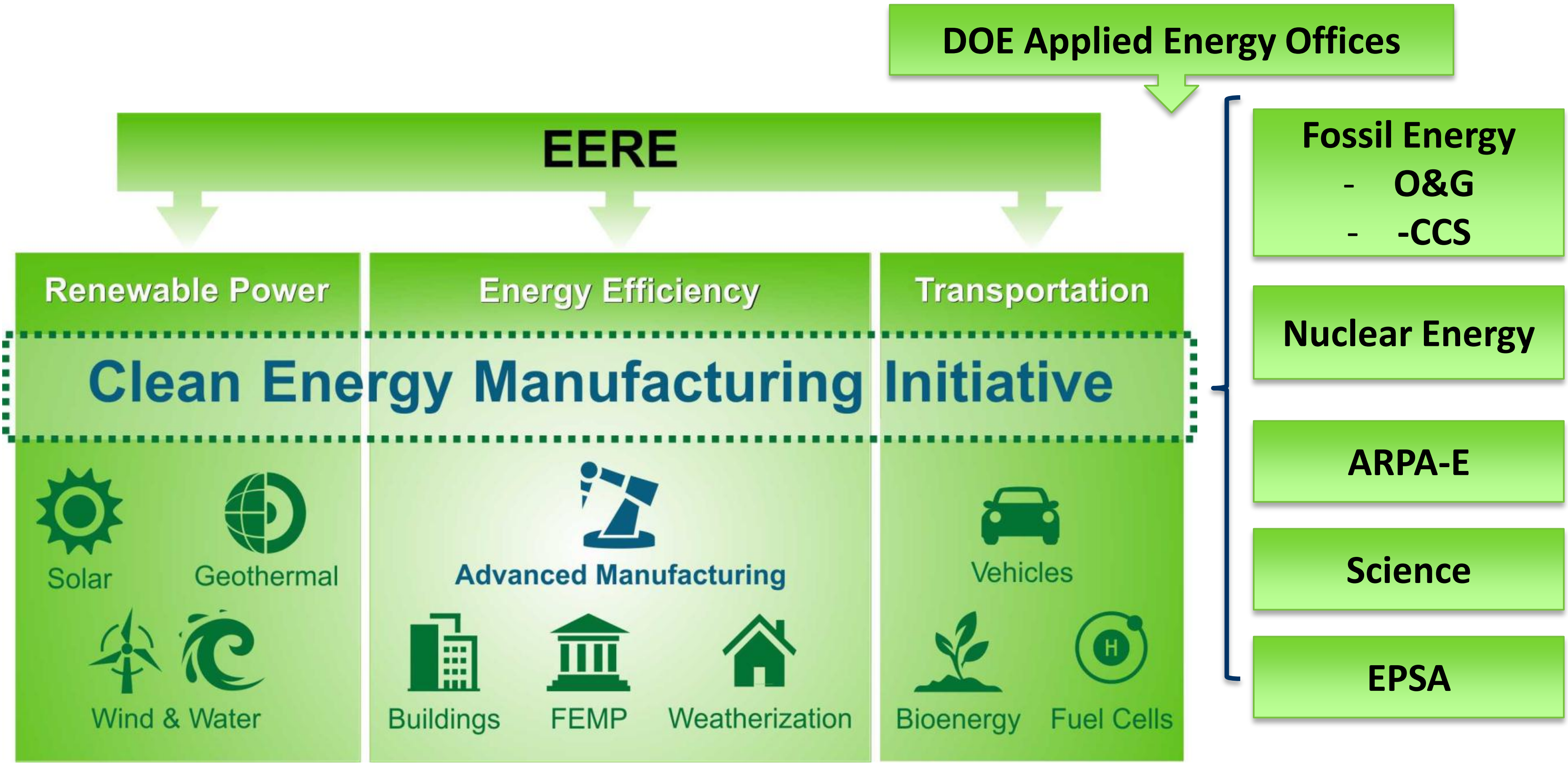
Clean Energy Manufacturing Initiative – Across DOE



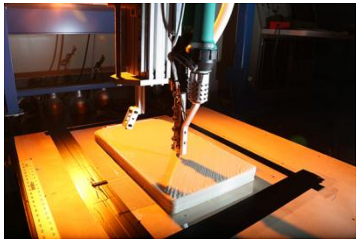
Collaboration toward:

- Common goal to collectively ***increase U.S. manufacturing competitiveness***

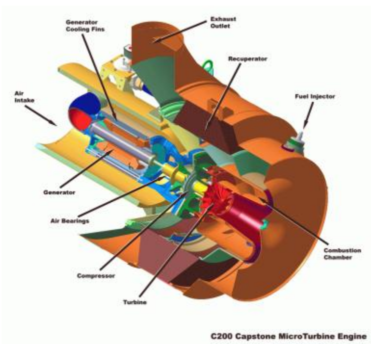
Coordination for:

- Comprehensive Strategy
- Collaborative Ideas

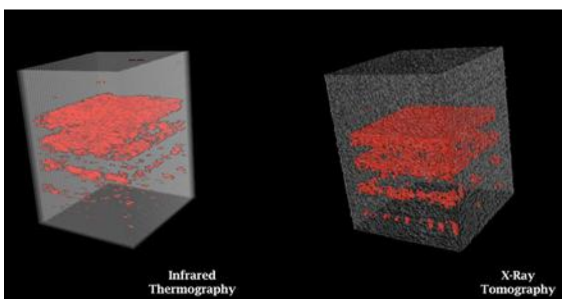
Advanced Manufacturing Office



Additive Manufacturing of Large Area Structures for Energy



Advanced Microturbine Systems for Distributed Generation and CHP



Computational Modelling, Infrared Detection and Tracking of Voids and Defects in High Performance Alloys

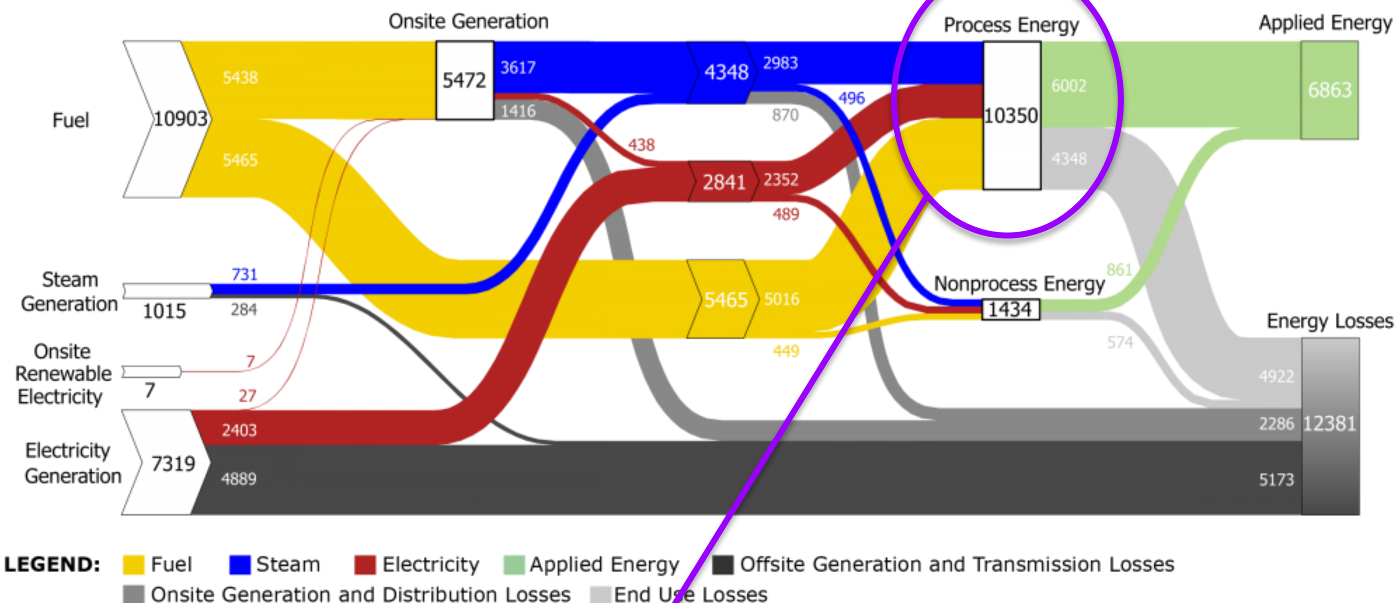
AMO's Purpose is to Increase U.S. Manufacturing Competitiveness and Energy Efficiency through:

- **Broadly Applicable Efficiency Technologies for Energy Intensive and Energy Dependent Manufacturing**
  - examples: combined heat and power (CHP), efficient manufacturing process intensification, energy management and process controls

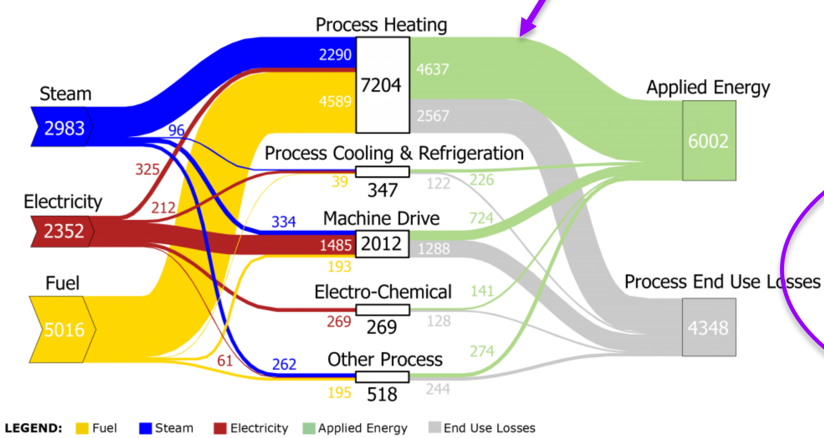
- **Platform Manufacturing Innovations for Advanced Energy Technologies**
  - examples: carbon fiber composites; critical materials; advanced materials manufacturing; high performance simulation, visualization and modelling, wide band gap semiconductors/ power electronics

Energy Use in the Manufacturing Sector

U.S. Manufacturing Sector (TBtu), 2010



Process Energy (TBtu), 2010



Estimated 20%-30% Improvement in Systems Efficiency Through How Manufacturing Systems are Operated

Requires Improved Situational Awareness and Decision Support For Manufacturing Systems: Intelligence in Manufacturing

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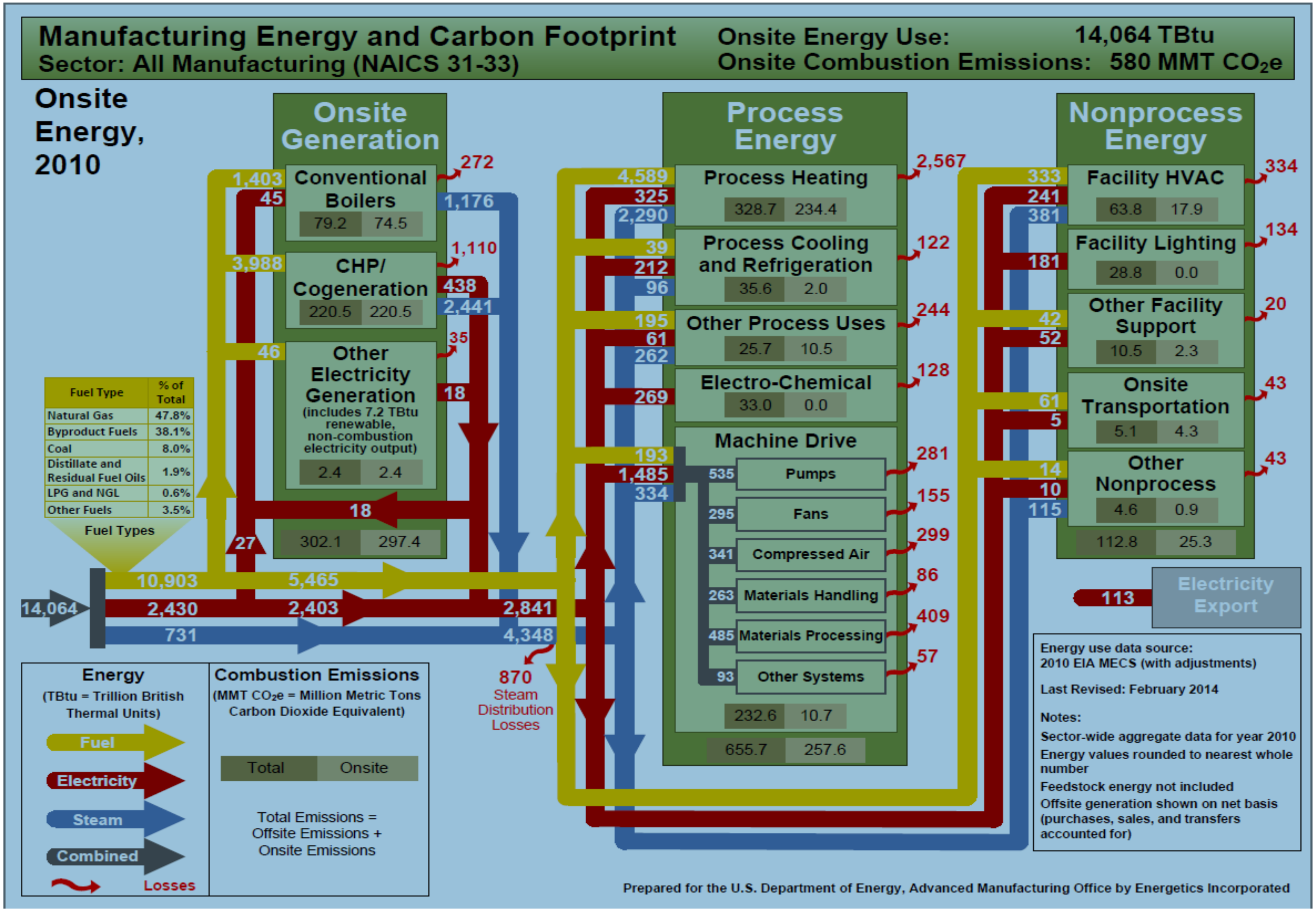
Deeper Look at Energy in Manufacturing



http://energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2010-mecs

Energy Intensive Industries

Primary Metals
1608 TBTU

Petroleum Refining
6137 TBTU

Chemicals
4995 TBTU

Wood Pulp & Paper
2109 TBTU

Glass & Cement
716 TBTU

Food Processing
1162 TBTU

Processes for Clean Energy Materials & Technologies

Energy Dependence: Energy Cost Considered in Competitive Manufacturing

Solar PV Cell

Carbon Fibers

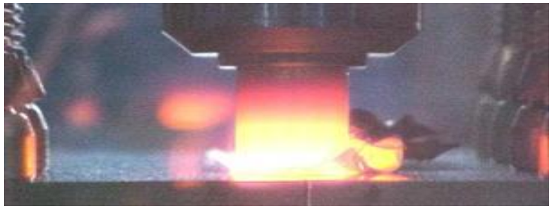
Light Emitting Diodes

Electro-Chromic Coatings

Membranes

EV Batteries

Multi-Material Joining



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Shared R&D Facilities

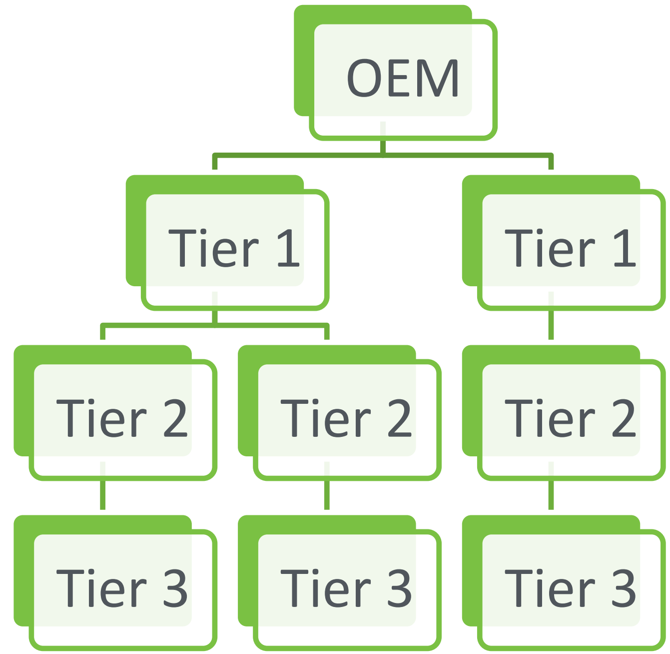
Address market disaggregation to rebuild the industrial commons

Then

Ford River Rouge Complex, 1920s

Photo: Library of Congress, Prints & Photographs Division, Detroit Publishing Company Collection, det 4a25915.

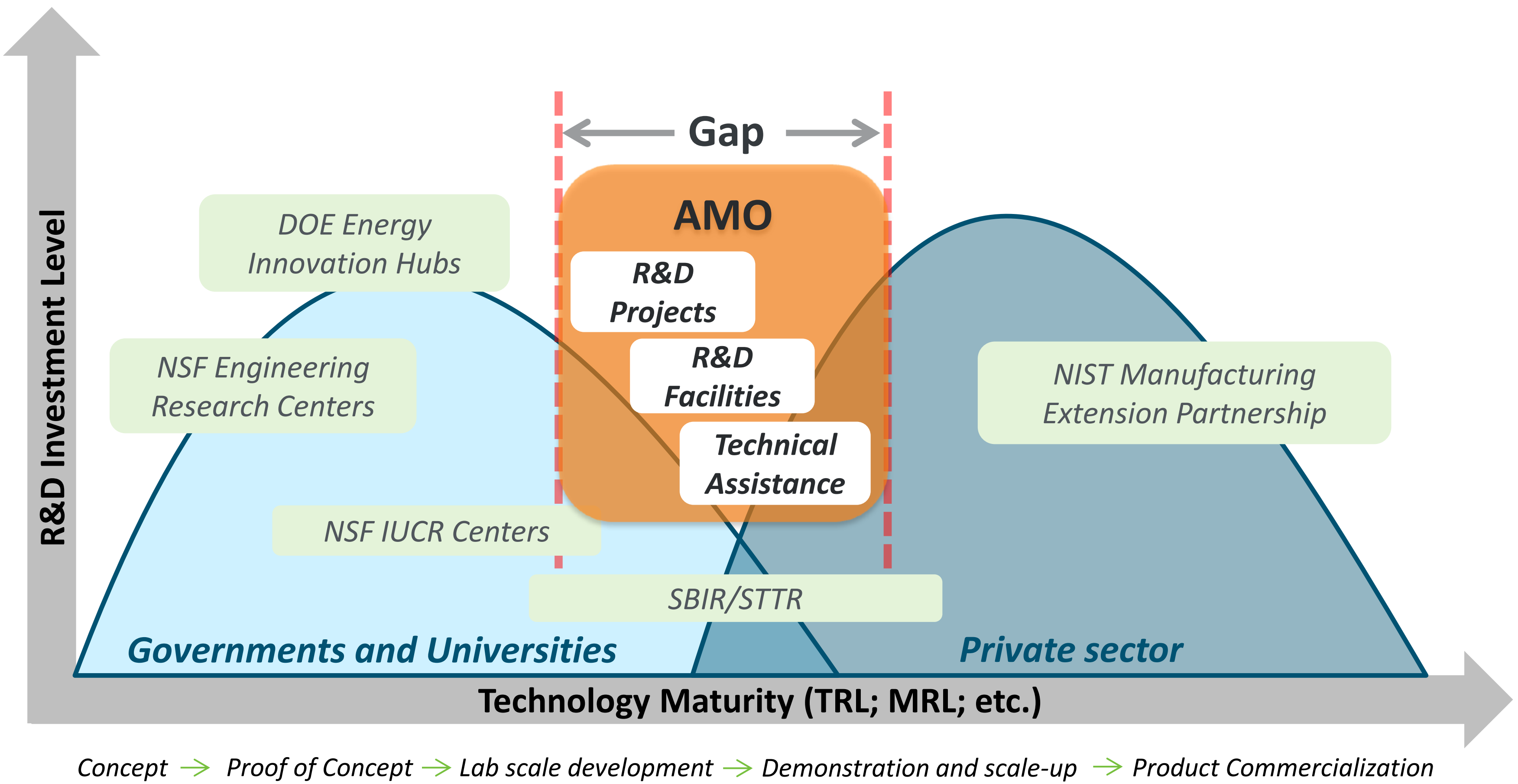
Now



How do we get innovation into manufacturing today?

Bridging the Gap to Manufacturing

AMO: Advanced Manufacturing Office



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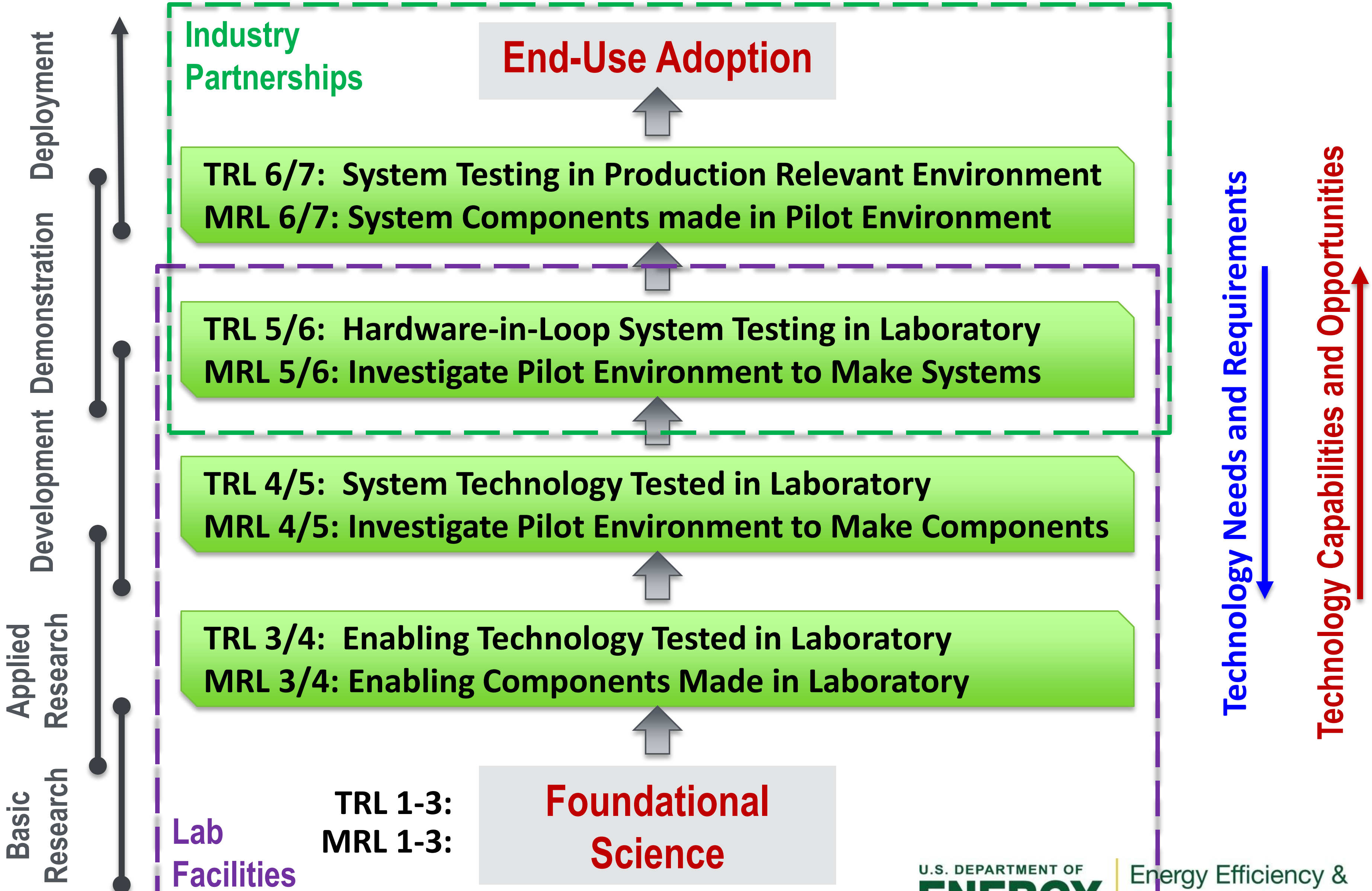
Manufacturing Technology Maturation



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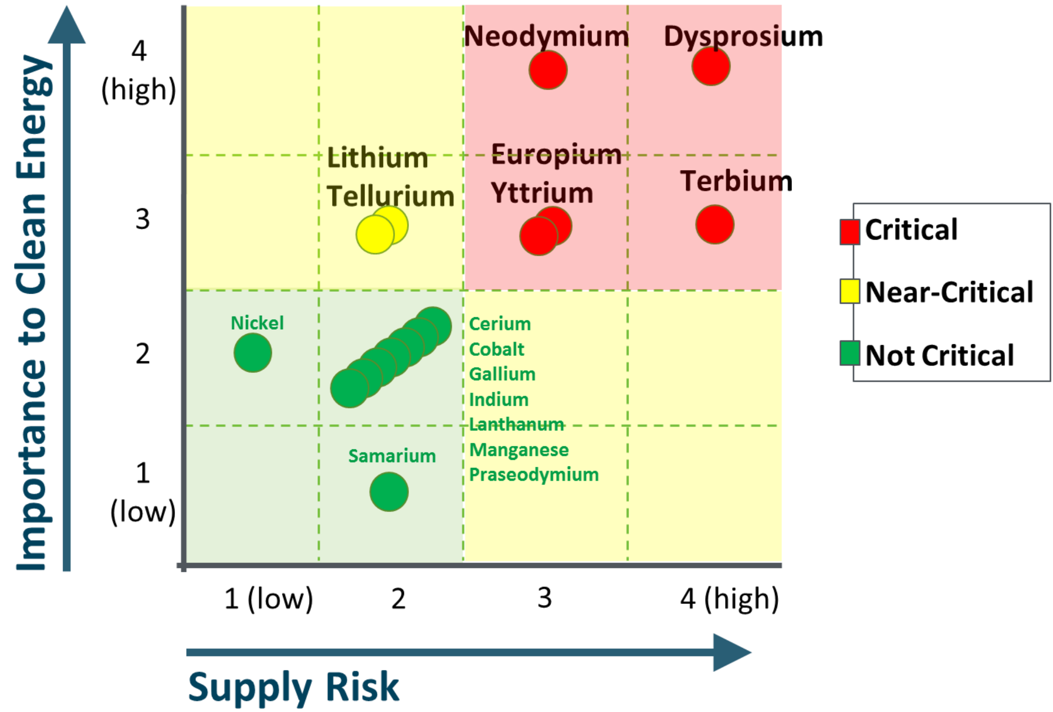
Accelerating Energy Innovations

Critical Materials Institute

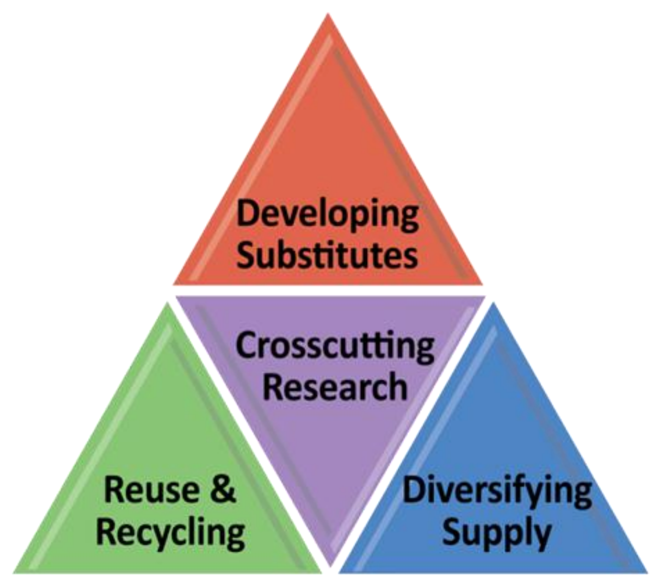
A DOE Energy Innovation Hub

- Consortium of 7 companies, 6 universities, and 4 national laboratories
- Led by Ames National Laboratory



	Dy	Eu	Nd	Tb	Y	Li	Te
Lighting		✓		✓	✓		
Vehicles	✓		✓			✓	
Solar PV							✓
Wind	✓		✓				

Critical Materials - as defined by U.S. Department of Energy, *Critical Materials Strategy*, 2011.



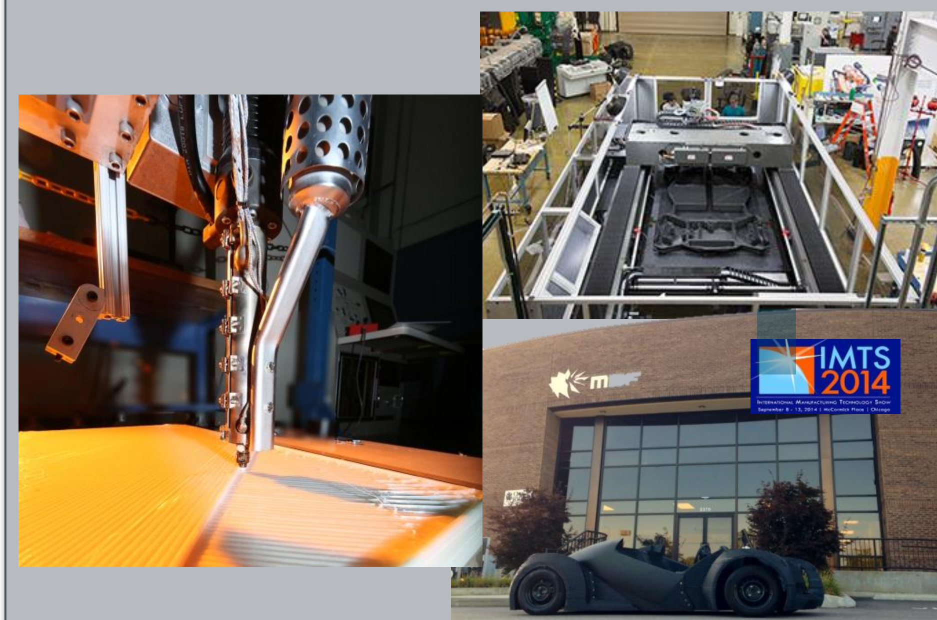
Manufacturing Demonstration Facility at Oak Ridge National Lab

America Makes

Supercomputing Capabilities

Spallation Neutron Source

Large Area Polymer Additive



Metal Additive

Arcam electron beam processing AM equipment

POM laser processing AM equipment

Program goal is to accelerate the manufacturing capability of a multitude of AM technologies utilizing various materials from metals to polymers to composites.

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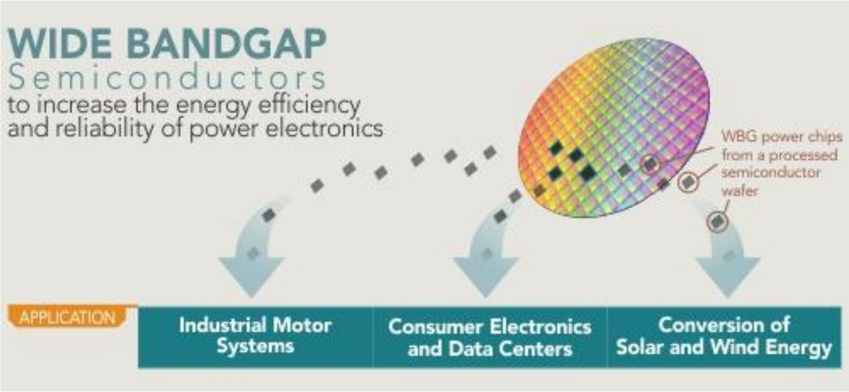
Power America

Lead: North Carolina State University

ABB, Arkansas Power Electronics International, Avogy, Cree, Deere & Company, Delphi Automotive, Delta Products, DfR Solutions, GridBridge, Hesse Mechatronics,, II-VI, IQE, Monolith Semiconductor, RF Micro Devices, Toshiba International, Transphorm, United Silicon Carbide, Vacon, Arizona State University, Florida State University, University of California-Santa Barbara, Virginia Tech, National Renewable Energy Lab, Naval Research Lab



Mission: **Develop advanced manufacturing processes that will enable large-scale production of wide bandgap semiconductors, which allow power electronics components to be smaller, faster and more efficient than silicon.**

President Obama
North Carolina State University, January 15, 2014

Poised to revolutionize the energy efficiency of power control and conversion

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Institute for Advanced Composite Materials Innovation

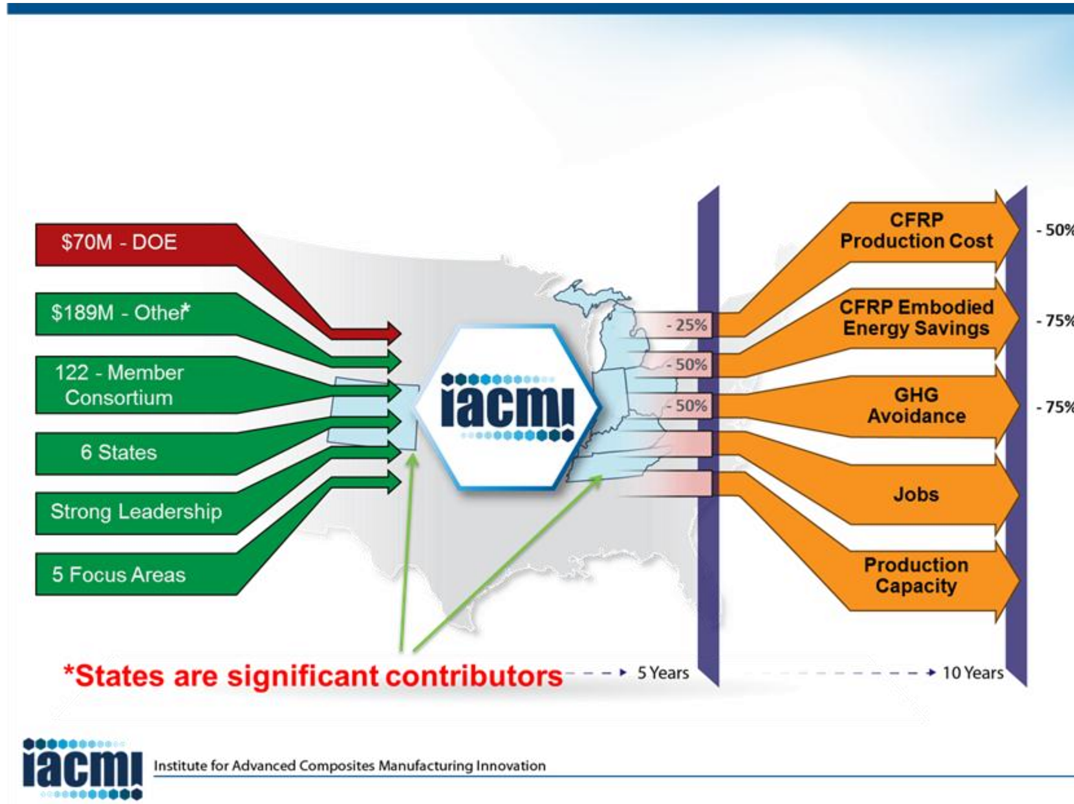
Objective

Develop and demonstrate innovative technologies that will, within 10 years, make advanced fiber-reinforced polymer composites at…

50% Lower Cost

Using 75% Less Energy

And reuse or recycle >95% of the material



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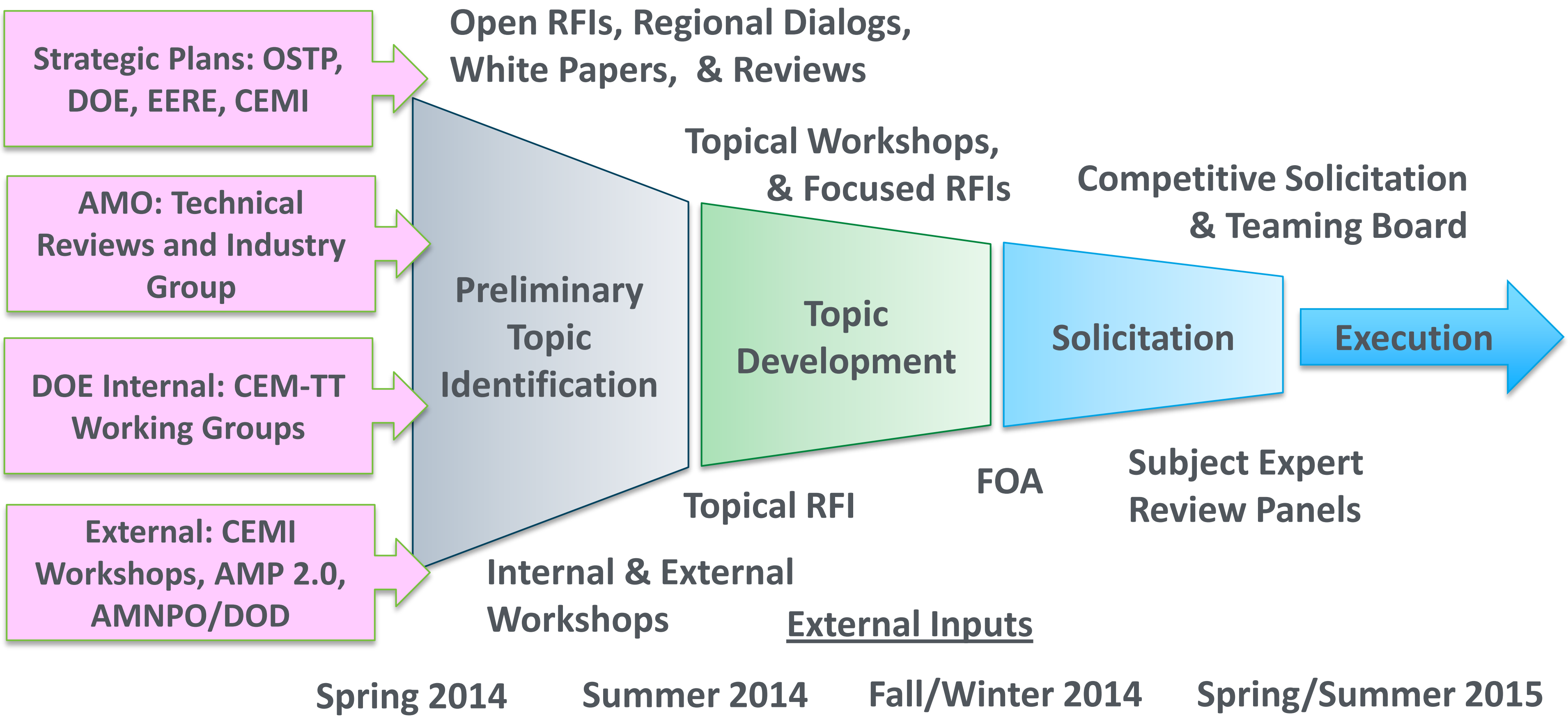
Getting to the Topic: Pathway To Date



Cross-cutting Technology Opportunities

Additive Manufacturing
Critical Materials
Wide E_g Power Electronics
Advanced Composites

Sensors, Control, Platforms & Models
Advanced Materials Manufacturing
Chemical Process Intensification
2D / Roll-to-Roll Manufacturing

CHP/DG & Grid Integration
Sustainable Manufacturing
Electric Machines

Manufacturing Sector Whitespace

Embedded Energy Intense Manufacturing

Energy Intensive Sector Focus Areas

- Metals
- Glass & Ceramics
- Forest & Biomass
- Petrochemicals
- Extraction
- Concrete

Clean Energy Applications

- Transportation
- Efficient Systems
- Power Generation
- Energy Delivery

Cross-Cutting Impact Opportunities

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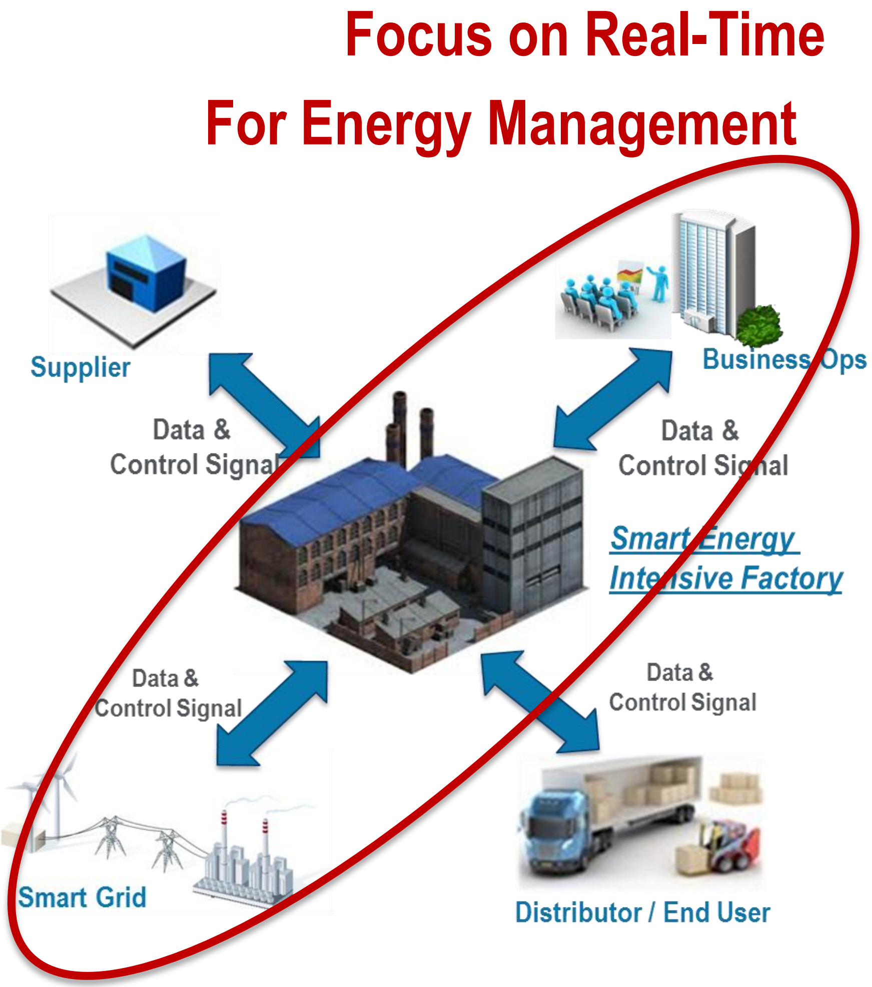
Broad Topical Areas

- **Platform Materials and Technologies for Energy Applications**
  - Advanced Materials Manufacturing (Mat'l Genome, Nanomaterials, etc.)
  - Critical Materials
  - Advanced Composites & Lightweight Materials
  - 3D Printing / Additive Manufacturing
  - 2D Manufacturing / Roll-to-Roll Processes
  - Wide Bandgap Power Electronics
  - Next Generation Electric Machines
- **Efficiency in Manufacturing Processes (Energy, CO_2)**
  - Advanced Sensors, Controls, Modeling and Platforms (ie. Smart Manf.)
  - Advanced Chemical Process Intensification
  - Grid Integration of Manufacturing (CHP and DR)
  - Sustainable Manufacturing (Water, New Fuels & Energy)
- **Emergent Topics in Manufacturing**

Questions We Asked: RFIs and Workshops

Core Questions	Application to NNMI Topic Selection
High Impact:	• What is manufacturing challenge to be solved? • If solved, how does this impact clean energy goals? • If solved, who will care and why specifically?
Additionality:	• Who is supporting the fundamental low-TRL research & why wouldn't they support mid-TRL development? • Who else might fund this mid-TRL development & how might EERE/AMO support catalyze this co-investment?
Openness:	• Has this mid-TRL manufacturing challenge been stated broadly? • Is there fertile low-TRL scientific base to address the challenge? • Has a broad set of stakeholders been engaged in dialog?
Enduring Economic Benefit:	• Would this manufacturing challenge impact more than one clean energy technology application? • Is industry currently trying to identify solutions?
Proper Role of Government:	• What is the national interest? What is the market failure? (Why would industry not solve this by itself?) • Is there a pathway for Federal funding to end & what are the metrics for this transition? • Is there large potential for follow-on funding, & what are the stage gates to follow-on support?
+ Appropriate Mechanism	• Why is this specific mid-TRL problem best addressed through a 5-Year, multi-participant, industry-oriented institute (NNMI) now?

SMART Manufacturing: Advanced Controls, Sensors, Models & Platforms for Energy Applications

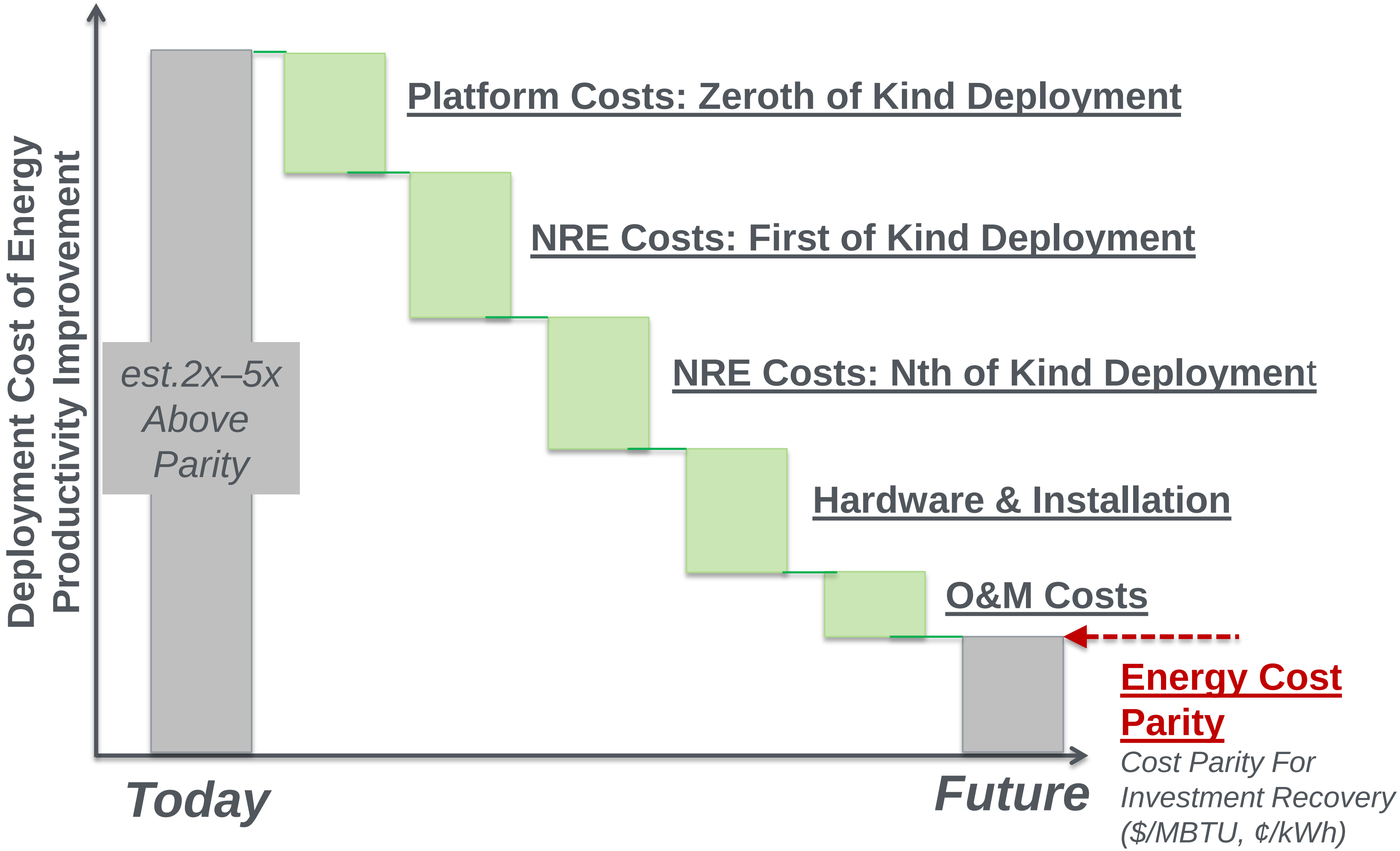


- Encompass machine-to-plant-to-enterprise real time sensing, instrumentation, monitoring, control, and optimization <u>of energy</u>
- Enable hardware, protocols and models for advanced industrial automation: requires a holistic view of data, information and models in manufacturing
- Leverage High Performance Computing for High Fidelity Process Models
- Significantly reduce energy consumption and GHG emissions & improve operating efficiency – **20% to 30% potential**
- Increase productivity and competitiveness across all manufacturing sectors:
  Special Focus on <u>Energy Intensive</u> & <u>Energy Dependent</u> Manufacturing Processes

Leverages AMP 2.0

Costs in Deploying Smart Information Systems

Possible Barriers to Adoption & Possible Path to Cost Parity



Notional Barriers to Widespread Adoption

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Technical Issues and Adoption Challenges

	Platform Challenges	1st of Kind Demonstration	Nth of Kind Demonstration	Hardware & Deployment	O&M
High Fidelity Modelling		X	X	X	
Data Architecture & Platform	X	X			X
Sensor Development & Qualification		X	X	X	X
Algorithms, Controls and Data		X	X	X	X
Demonstration Testbeds (1st of Kind)		X		X	X

Notional Technical Issues Related to Adoption Challenges

Smart Manufacturing & Digital Manufacturing

	Digital Manufacturing	Smart Manufacturing
Emphasis	Information technology focus for highly integrated design and manufacturing of products and processes	Advanced Sensors, Controls, Platforms and Modeling for Manufacturing including Process Simulation and Control
Description	"digital thread" allowing all manufacturing to pass design and process information up and down the supply chain	Unprecedented real-time control of energy, productivity, and costs across factories and companies
Core Technical & Process Areas	Intelligent machines with integrated IT machine to machine communication, across platforms and companies; computer simulation, 3D models, Model Based Enterprise, interoperable systems, design of advanced materials and processes, & analytics	Advanced sensing, instrumentation, monitoring, control, and process optimization using both advanced hardware and software platforms, as well as modeling and simulation technologies
Key Benefit	Reduced cost and time; faster marketplace penetration of new products	Save money, conserve energy, greater efficiency, real-time control of manufacturing processes and supply
Applicable Industries	All manufacturing	Energy-intensive and Energy-dependent
Potential Savings	Accuracy - "First part correct," correct by design, correct by construction, and automatic verification and correction	10-20% reduction in the cost of production, largely by optimization of energy use and energy productivity
Cyber Security	Life-Cycle (entire digital thread)	Real Time (sensors and controls)

http://manufacturing.gov/docs/Digital-vs-Smart-Mfg-Inst-Comparison.pdf

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What does Success Look Like?

Energy Products
Invented Here…

…And Competitively
Made Here!

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Thank You

Questions?